SIMULATION AND FLOW ANALYSIS THROUGH DIFFERENT PIPE GEOMETRY

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF

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In

Civil Engineering

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NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA

CERTIFICATE

This is to certify that the Project Report entitled **“Simulation and Flow Analysis Through Different Pipe Geometry”**submitted by **Vikalesh Kumar** in partial fulfillment for the requirement for the award of Bachelor in Technology degree in Civil Engineering at National Institute of Technology, Rourkela, is an authentic work carried out by him under my supervision and guidance. To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any degree or Diploma.

Date-

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ACKNOWLEDGEMENT

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I would like to thank all my professors as without the knowledge with which they have graciously provided me with this thesis would not have been possible.

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Finally I would like to thank my parents and friends for their continuous support and keeping me motivated in difficult times.

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ABSTRACT

In this project "Simulation and Flow Analysis Through Different pipe geometry" an exertion has been made to make point by point study of flow through pipe and figure the losses in head because of change in geometry. Losses in head due to change in geometry is important part to analyse the flow through pipes. I have tried to calculate losses occurs due to change in geometry by the experiment and also with the help of ANSYS software. I have also modeled different geometry like sudden contraction, sudden expansion and elbow and also try to show the effect of

change in velocity of flow, drop in pressure head and effect of static pressure, dynamic pressure and stream flow due to change in geometry.

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CHAPTER 1

INTRODUCTION

1.1 GENRAL:

Pipe flow, an extension of Hydraulics and Fluid Mechanics, is a kind of fluid flow inside a shut (conduit in the feeling of a method for regulation). The other kind of flow inside a conduit is open channel flow. These two kinds of flow are comparable from numerous points of view, yet contrast in one paramount appreciation. Pipe flow, being kept to shut conduit, does not push immediate environmental weight, however does push pressure driven weight on the conduit. Not all flow inside a shut conduit is acknowledged pipe flow. Storm sewers are shut conduits yet typically keep up a free surface and thusly are viewed as open-channel flow. The special case to this is the point at which a storm sewer works at full limit, and afterward can get to be pipe flow. Energy in pipe flow is communicated as head and is characterized by the Bernoulli comparison. So as to conceptualize head along the course of flow inside a pipe, outlines regularly hold a water driven evaluation line. Pipe flow is liable to frictional losses as characterized by the Darcy-Weisbach formula. At the point when a fluid flows through a pipe, the fluid encounters a few resistances because of which some energy of the fluid is lost. The conduct of pipe flow is legislated fundamentally by the impacts of viscosity and gravity with respect to the inertial forces of the flow. Contingent upon the impact of viscosity in respect to inertia, as spoke to by the Reynolds number, the flow might be either laminar or turbulent. At a Reynolds number beneath the discriminating worth of roughly 2040 pipe flow will eventually be laminar, while over the basic quality turbulent flow can persevere. Likewise, the move between laminar flow and turbulence could be delicate to unsettling influence levels and defects.

1.2 OBJECTIVES

- Calculate the minor losses(due to sudden expansion, sudden contraction and bend) in lab and find the co-efficient of loss for their geometry.
- Modeling of different pipe geometry like elbow, sudden enlarge, sudden contract pipe etc. in ANSYS software.
- Simulation of fluid flow through these pipe.
- Calculation of minor losses with the help of ANSYS.
- Comparison of ANSYS obtained results with experimental observations and result.

CHAPTER 2

LITERATURE REVIEW

2.1 LOSSES IN PIPES

when afluid flow through a pipe, the fluid experiences some resisitance due to which there are some loss in energy of fluid.

This loss of energy is classified as:

1. Major Energy losses
    a) Darcy-Weisbach formula
    b) Chezy's formula
2. Minor losses
    a) Bend in Pipe
    b) Sudden contraction
    c) Sudden expansion
    d) Pipe fitting

An obstruction in Pipe

2.2 ENERGY LOSS DUE TO FRICTION

Friction loss is the loss of energy or "head" that happens in pipe flow because of viscous impacts created by the surface of the pipe.friction Loss is recognized as a "major loss" and it is not to be befuddled with "minor loss" which incorporates energy lost because of blocks. The shear stress of a flow is likewise subject to whether the flow is turbulent or laminar. For turbulent flow, the weight drop is subject to the roughness of the surface, while in laminar flow, the roughness impacts of the wall are irrelevant. This is because of the way that in turbulent flow, a slender viscous layer is shaped close to the pipe surface which causes a loss in energy, while in laminar flow, this viscous layer is non-existent.

Friction loss has a few reasons, including:

• frictional losses rely on upon the states of flow and the physical properties of the system.

• movement of fluid atoms against one another.

• movement of fluid atoms against within surface of a channel .

•bends, wrinkles, and other sharp turns in hose or channeling.

In channel flows the losses because of contact are of two type: skin-rubbing and structure-grinding. The previous is because of the roughness of the inward a piece of the channel where the fluid interacts with the pipe material, while the recent is because of obstructions present in the line of flow- -maybe a curve, control valve, or anything that changes the course of movement of the flowing fluid.

1. **Darcy-Weisbach Formula:** It is a method to calculate friction loss resulting from fluid motion in pipes is by using the Darcy-Weisbach Equation. For a circular pipe:

$$h_i = \frac{flv^2}{2gD}$$

Where,

h_i=Head loss due to friction in unit of length

f= friction factor

D = Pipe Diameter

V = Flow velocity

2. **CHEZY'S FORMULA:**

V=C$\sqrt{mi}$

Where,

V=mean velocity of flow

C=Chezy's constant

m=hydraulic mean depth

2.3 MINOR LOSSES IN PIPE

Energy loss due to friction is known as major loss while the loss of energy occurs due to change in velocity(magnitude or direction) is called minor loss of energy.

Minor losses termed as;

$$h = k\frac{v^2}{2g}$$

Where K is the loss coefficient.

Each geometry of pipe entrance has an associated loss coefficient.

The minor loss of energy(or head) happen in following cases:

1. Loss of head due to bend in the pipe.
2. Loss of head due to sudden expansion.
3. Loss of head due to contraction.
4. Loss of head due to different pipe fitting.
5. Loss of head due to entrance of a pipe.
6. Loss of head due to exit of a pipe.
7. Loss of head due to obstruction in a pipe.

2.3.1 Loss of head due to sudden expansion:

Because of sudden change in diameter across of the pipe from D_1 to D_2, the fluid flowing through from the more modest pipe is not fit to the unexpected change of the boundary. This the flow separate from the boundary and turbulent eddies shaped as indicated in fig 2.1. The loss of head due happen because of the creation of these eddies.

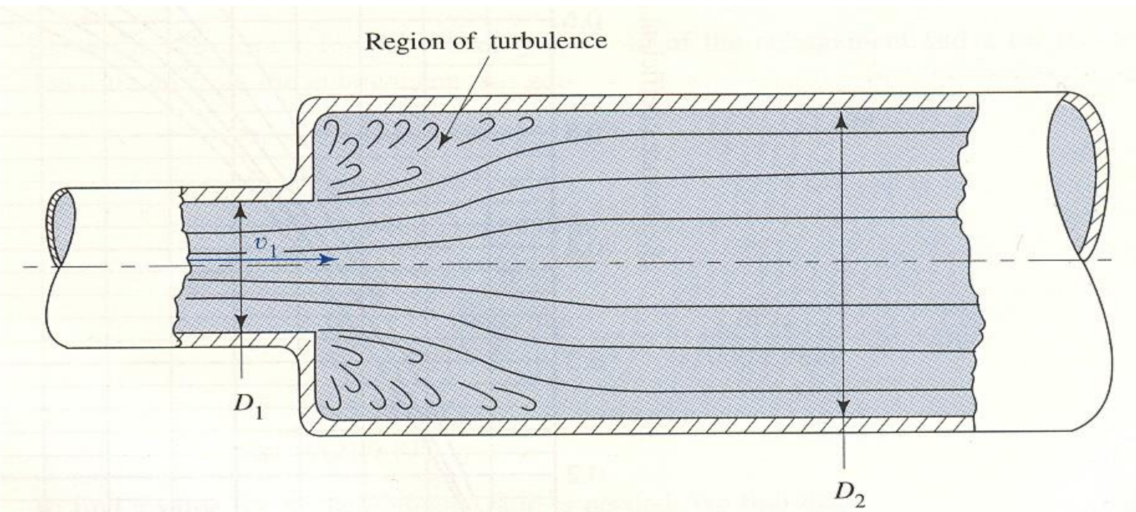


Fig 2.1 sudden expansion

Energy lost is a result of turbulence. Measure of turbulence relies on upon the difference in pipe diameters.

Head loss

$$h_e = k_e \frac{{v_1}^2}{2g}$$

where,

h_e= loss in head due to expansion.

v_1=velocity at D_1

2.3.2 Loss due to sudden contraction:

Sudden contractions are the point at which the area of the pipe diameter reduce suddenly along the length of the channel (at a 90 degree plot). The downstream velocity will be higher than the upstream velocity. Here also the streamlines cannot follow the abrupt change of geometry and hence gradually converge from an upstream section of the larger tube. Then again, instantly downstream of the junction of region compression, the cross-sectional zone of the stream tube turns into the minimum and short of what that of the more modest pipe. This section of the stream tube is known as vena-contracta , after which the stream widens again to fill the pipe.

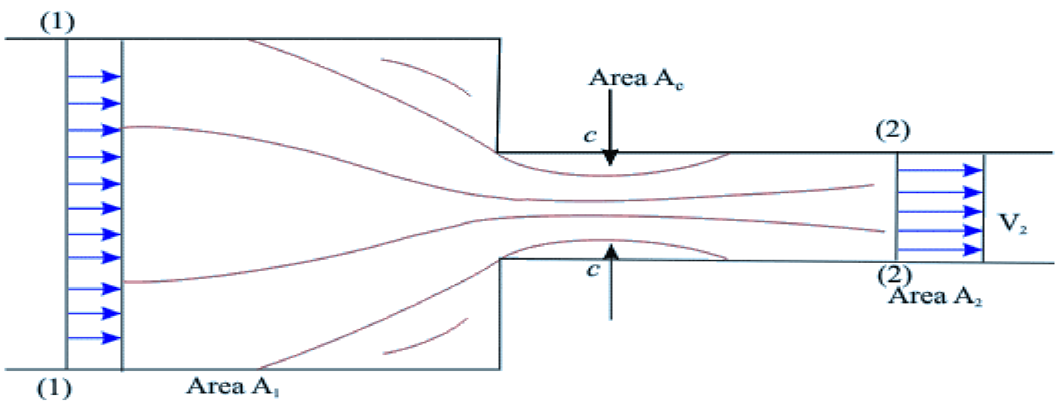


Fig 2.2 vena-contracta formed in sudden contraction.

Head loss $h_c = k_c \frac{{v_2}^2}{2g}$,

Where, v_2=velocity at smaller diameter

Kc=co-efficient of loss due to contraction

2.3.3 Loss of head due to bend in pipe

Bends are given in pipes to alter the course of flow through it. An additional loss of head, separated from that because of liquid friction, happens in the course of flow through pipe bend.

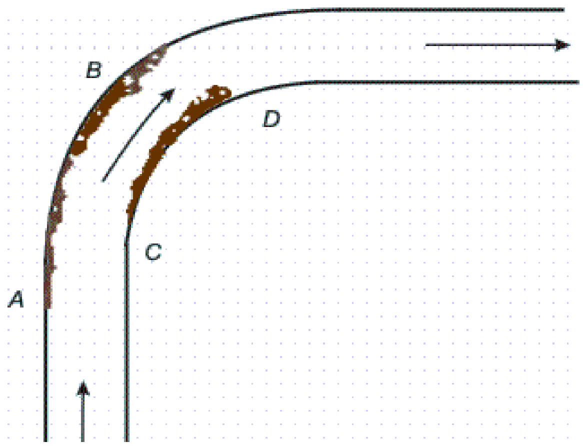


Fig2.3 BEND IN PIPE

Whenever a fluid flows in a curved path, there must be a force acting radially inwards on the fluid to provide the inward acceleration, known as centripetal acceleration . Fluid particles in this region, because of their close proximity to the wall, have low velocities and cannot overcome the adverse pressure gradient and this leads to a separation of flow from the boundary and consequent losses of energy in generating local eddies. Losses also take place due to a secondary flow in the radial plane of the pipe because of a change in pressure in the radial depth of the pipe.

Loss in head due to Bend is expressed as:

$$h_b = k_b \frac{v^2}{2g}$$

Where, k_b= co-efficient of loss due to bend

V=velocity of flow in pipe

CHAPTER 3

METHODOLOGY

3 METHODOLOGY

After deciding the topic first step of my project is go through the literature review of the topic. I started search for previous work related to this topic and study that and start my project. Next step of my project is collect the data required for project. I needed the dimension of different geometry of pipe, flow speed, specification of liquid which is flow through pipes. After finding these data, I started my project in lab by did experiment of minor losses. Then I did modeling these different geometry in ANSYS and after mess generation, I specified proper property of pipes and liquid flow through its. Finally calculation is done in ANSYS for different parameter(velocity, pressure,turbulence) and obtained contours of these parameter and finally generate the report and calculate losses with the help of ANSYS.

CHAPTER 4

PROCEDURE OF EXPERIMENT

4.1 STEPS

1. First of all bench valve, the gate valve and the flow control valve are opened and after that the pump is statrted to fill the test rig with water.
2. Air is bleed from the pressure tap points, if present and the manometers by Adjusting the bench and flow control valves and air bleed screw.
3. All manometer levels lie within the scale is checked when all the valves are fully opened.The level is adjusted with the help of air bleed screw and the hand pump.
4. The reading is recorded for a selected flow from all the manometers after the water levels have steadied.
5. The flow rate is determined by accumulating some fix volume of water in volumetric storage tank with the help of stopper. A diital stopwatch is used for reord time and sight the volumetric tank to find the volume.
6. Step 4 and 5 is repeated for two more flow.
7. The flow rate is adjusted by the control valve and pressure drop across the gate valve is measured from the pressure guage.
8. Step 7 is repeated for more two flow rates.

Fig4. Minor losses apparatus

CHAPTER 5

OBSERVATION AND CALCULATION

5.1 SUDDEN EXPANSION

5.1.1EXPERIMENTAL OBSERVATION AND CALCULATION

OBSERVATION: FOR SUDDEN EXPANSION

Diameter of the smaller pipe before expansion is 19mm and after expansion is 25.4mm.

Diameter of larger pipe before expansion is 25.4mm and after expansion is 38.1mm.

Table5.1: Observation of sudden expansion.

Sl No	Rise in level(cm)	Volume (cm^3)	Time (sec)	Discharge $(m^3/\sec)$	Manometer Difference (mm)	Head (m)	V_1 (m/sec)	K_e
Pipe 1	10	9000	6	1.5×10^{-3}	25	0.315	5.29	0.22
Pipe 1	10	9000	7	1.3×10^{-3}	19	0.24	4.8	0.2
Pipe 2	10	9000	8	1.1×10^{-3}	7	0.084	2.17	0.35
Pipe 2	10	9000	14	6.43×10^{-4}	2.5	0.03	1.26	0.33

5.1.1 SAMPLE CALCULATION:

For pipe 1

$$h_e = k_e \frac{{v_1}^2}{2g};$$

$$k_e = \frac{2gh_e}{{v_1}^2} = \frac{2\times9.81\times0.315}{5.29^2} = 0.22$$

5.1.2 FROM ANSYS

a) Modeling

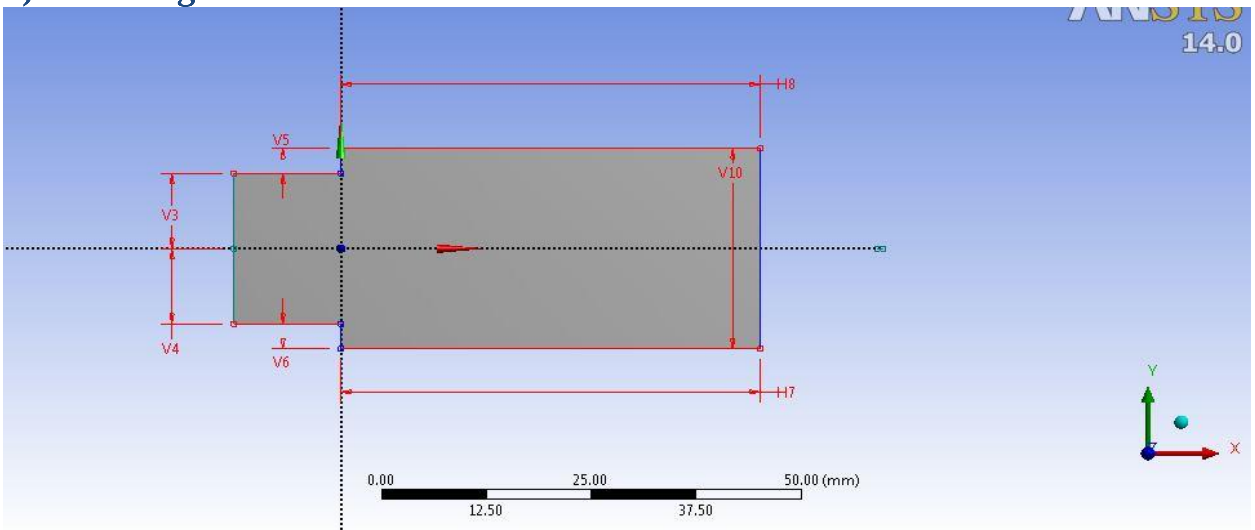


Fig 5.1: Geometry of sudden expansion pipe

b) Meshing

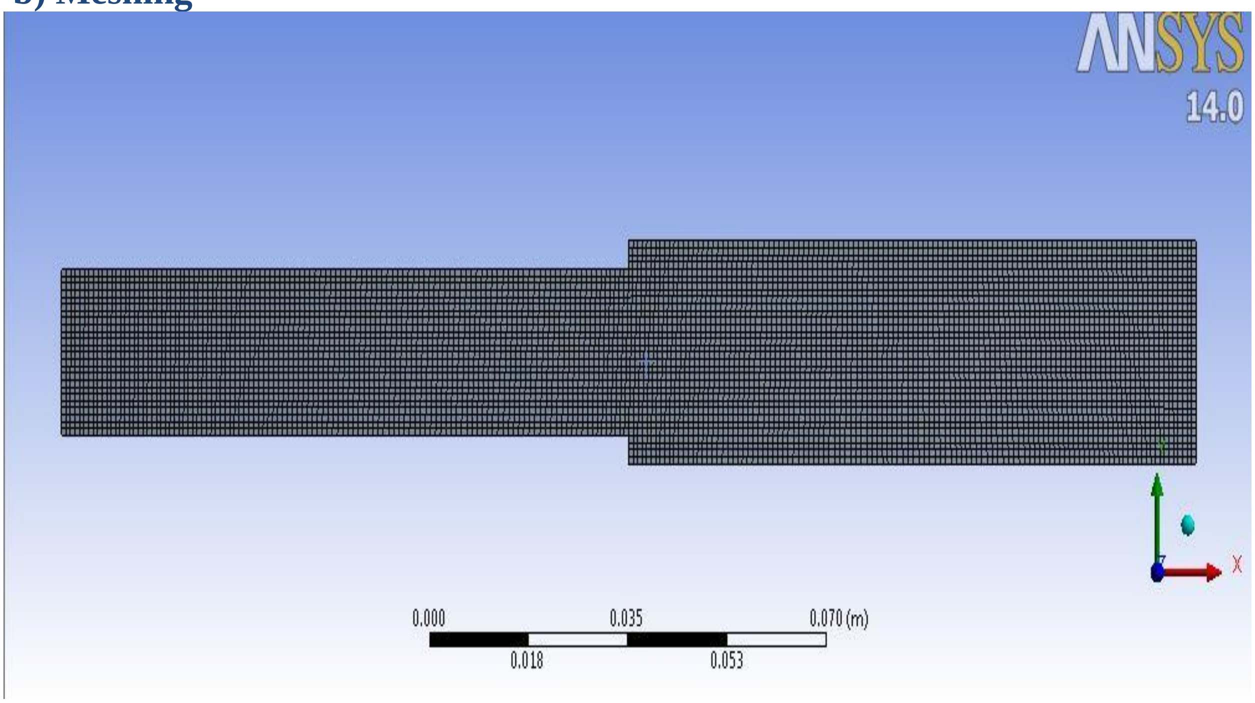


Fig 5.2: Mesh of sudden expansion pipe

a) Stream function

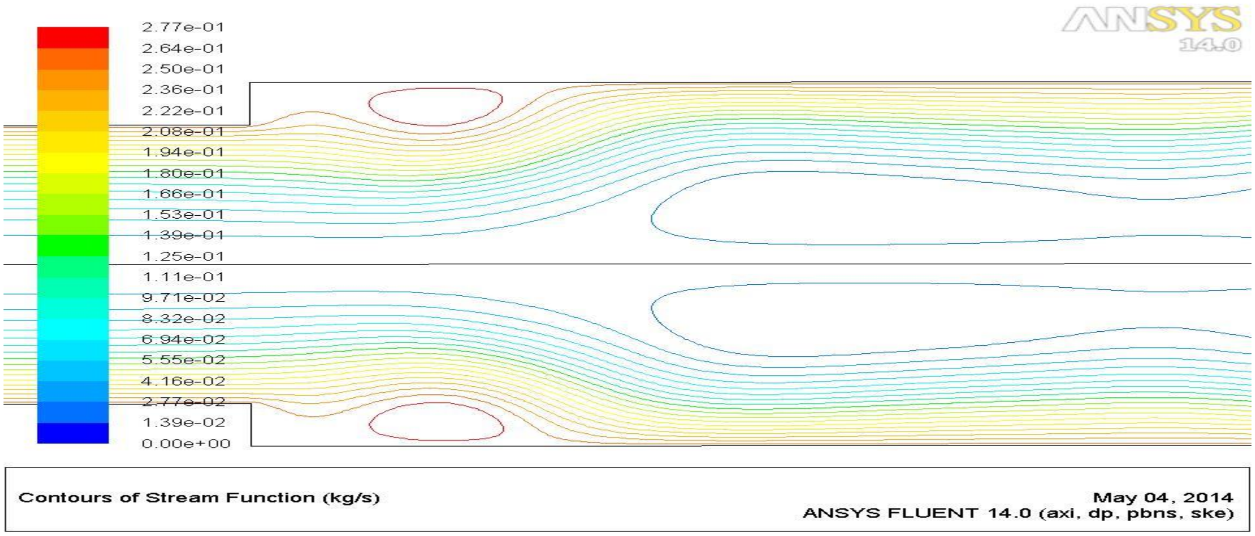


Fig 5.3: Stream function of flow

Just after junction stream line at the surface is disconnected and formation of eddies occur and Further touch the surface.

b) Absolute Pressure

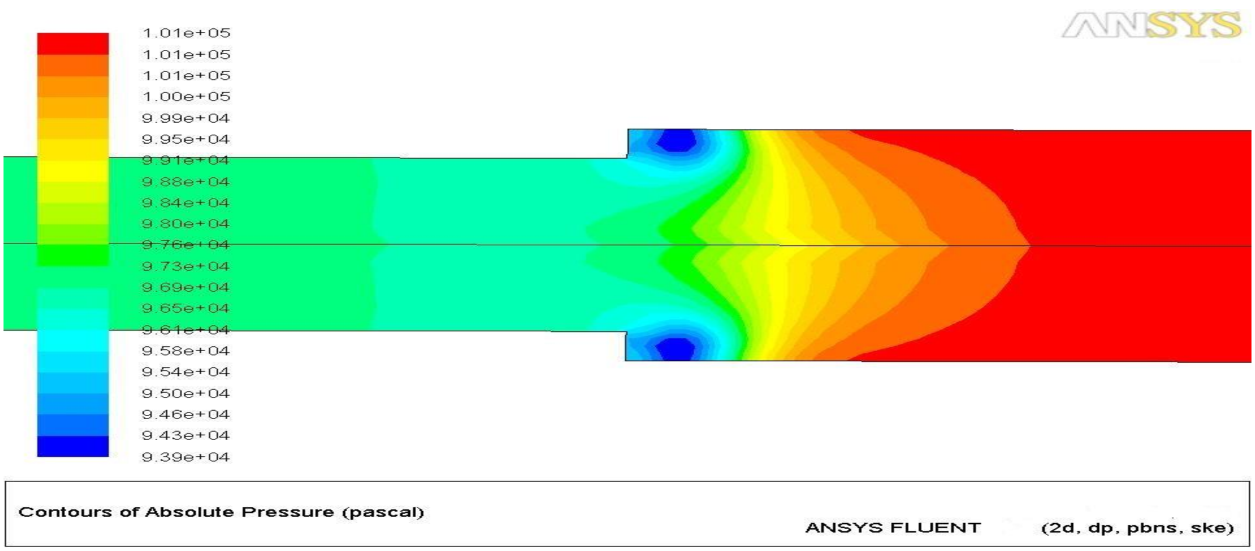


Fig 5.4: Contours of absolute pressure in pipe

At the inlet pressure is constant and near the junction variation in pressure can shown and outlet .

pressure is much more than inlet.

c) Velocity

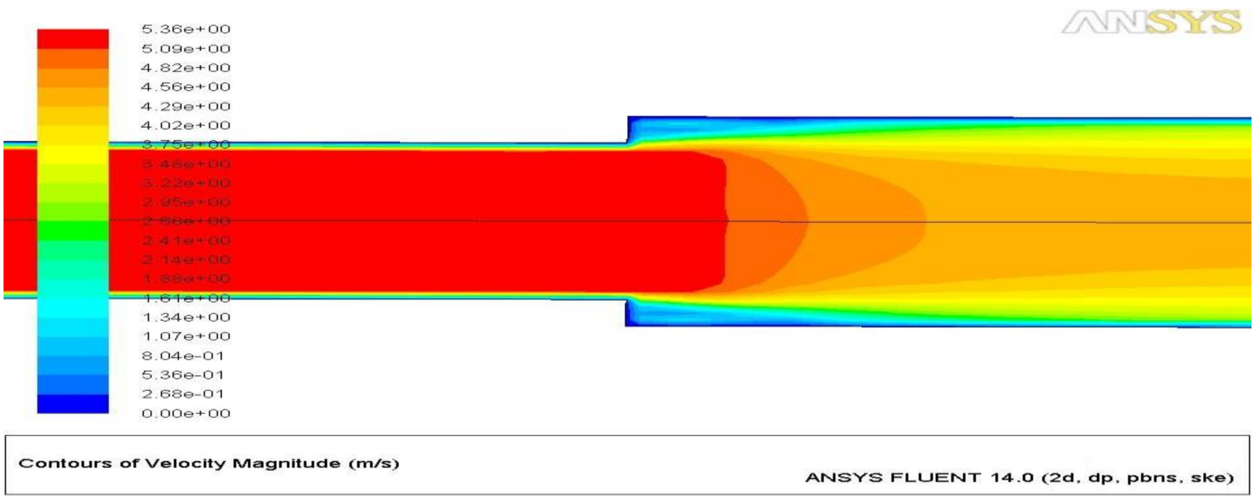


Fig 5.5: Contours of velocity magnitude

There is decrease in velocity of fluid when it reaches at the junction. Right of the junction velocity decreases in right direction and after some distance starting flow in steady state and velocity at outlet is less than inlet.

d) Dynamic pressure

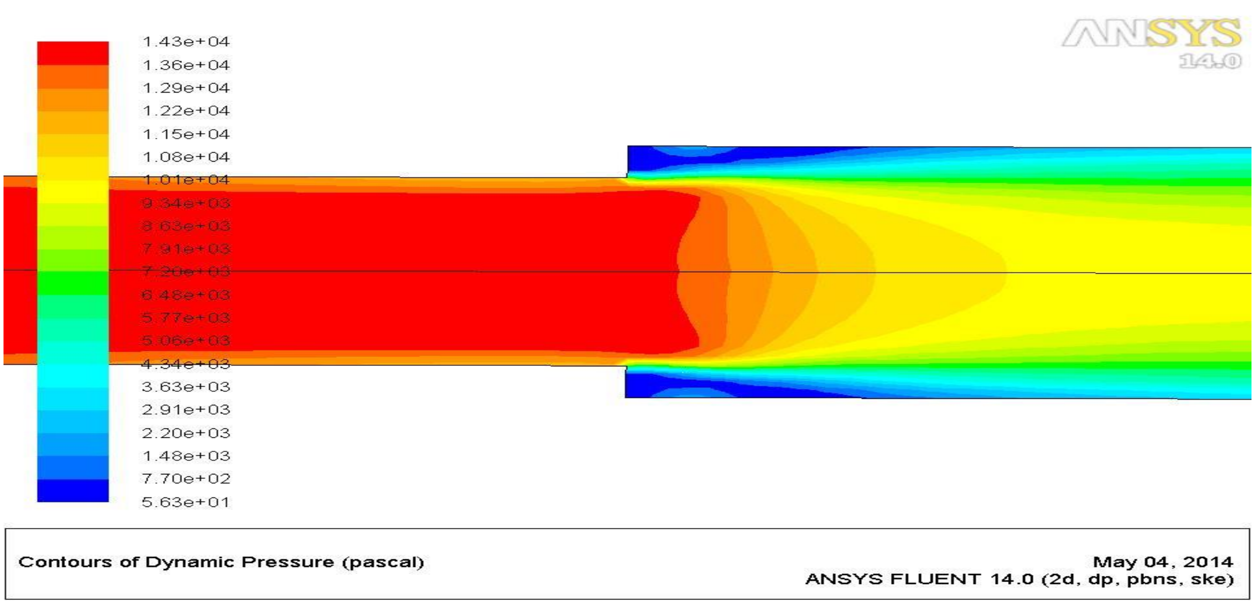
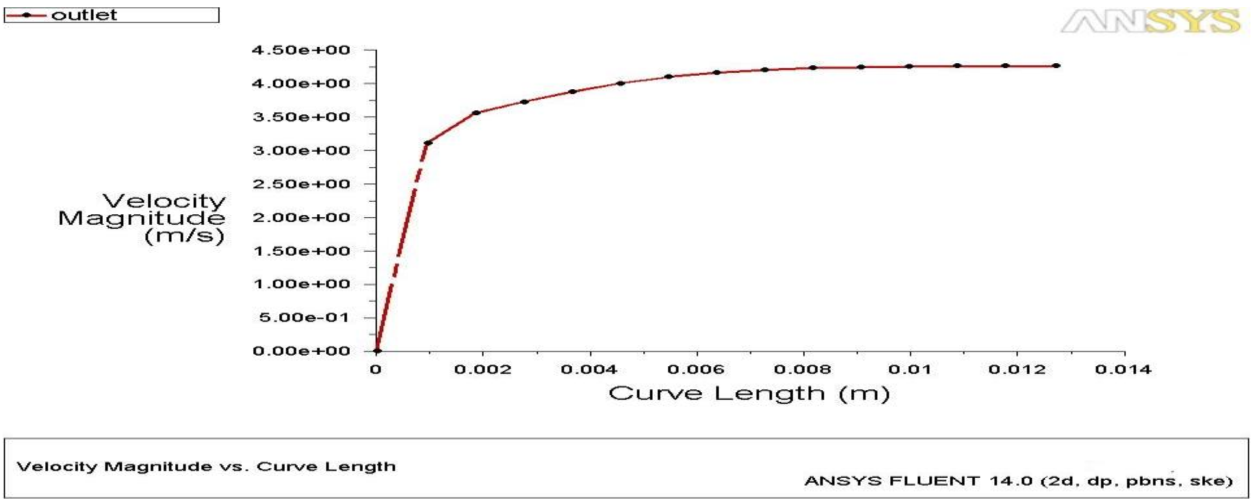


Fig 5.6: Contour of dynamic pressure

It is nearly same as velocity contour because dynamic pressure is directly propotional to square of velocity.



Graph 5.1: velocity variation at the outlet surface

At the pipe surface velocity is zero and it is increase as go away from surface to towards axis and velocity is maximmum at the axis.

5.1.2 CALCULATION:

Pressure at outlet=1.01$\times 10^5 Pa$.

Pressure at outlet=9.73$\times 10^4 Pa$.

Difference in pressure=1.01$\times 10^5$-9.73$\times 10^4$=3.7$\times 10^3 Pa$.

Head difference=$\frac{3.7\times10^3}{\rho g}$=$\frac{3.7\times10^3}{1000\times9.81}$ =0.377m

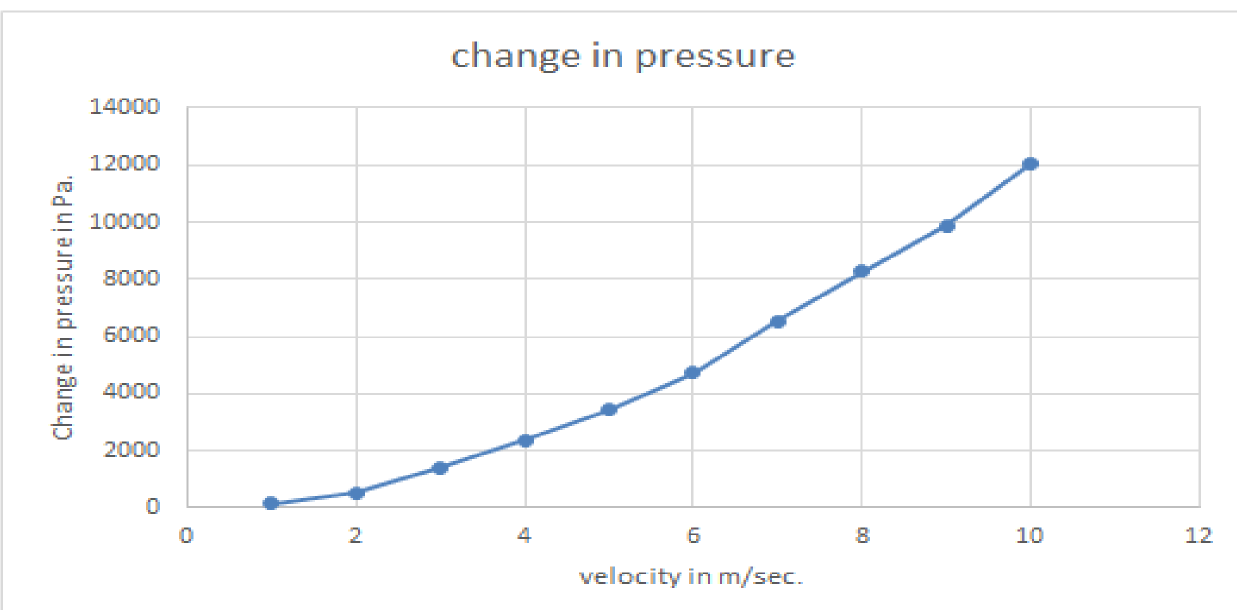
$h_e = k_e \frac{{v_1}^2}{2g}$;

$k_e = \frac{2gh_e}{{v_1}^2}$=$\frac{2\times9.81\times0.377}{5.29^2}$=0.26

Table 5.2:

Change in pressure and corresponding head between inlet and outlet at different velocity

Velocity(m/s)	change in pressure(Pa)	head loss(m)
1	133.7	0.013655
2	516	0.0527
3	1411.3	0.144137
4	2365.9	0.241631
5	3410	0.348266
6	4727.2	0.482793
7	6517.65	0.665653
8	8270.7	0.844694
9	9863.4	1.007357
10	12016.4	1.227245



Graph 5.2: Variation of pressure difference at different velocity

5.2 SUDDEN CONTRACTION

5.2.1 EXPERIMENTAL OBSERVATION AND CALCULATION

OBSERVATION

Table 5.3: For sudden contraction

Sl No	Rise in level(cm)	Volume (cm^3)	Time (sec)	Discharge (m^3/sec)	Manometer Difference (mm)	Head (m)	V_1 (m/sec)	v_2 (m/sec)	K_c
Pipe 1	10	9000	6	1.5×10^{-3}	24	0.315	2.97	5.29	0.22
Pipe 1	10	9000	11	8.18×10^{-4}	7.1	0.106	1.62	2.89	0.4
Pipe 2	10	9000	10	9×10^{-4}	4.05	0.051	0.995	1.77	0.31
Pipe 2	10	9000	11	8.18×10^{-4}	3.25	0.054	0.905	1.61	0.41

5.2.1 CALCULATION:

For pipe 1

$$h_c = k_c \times \frac{{v_2}^2}{2g};$$

$$k_c = \frac{2gh_c}{{v_2}^2} = \frac{2 \times 9.81 \times 0.315}{5.29^2} = 0.22$$

For pipe 2

$$h_c = k_c \times \frac{{v_2}^2}{2g};$$

$$k_c = \frac{2gh_c}{{v_2}^2} = \frac{2\times9.81\times0.051}{1.77^2} = 0.31$$

5.2.2 FROM ANSYS

a) Modeling

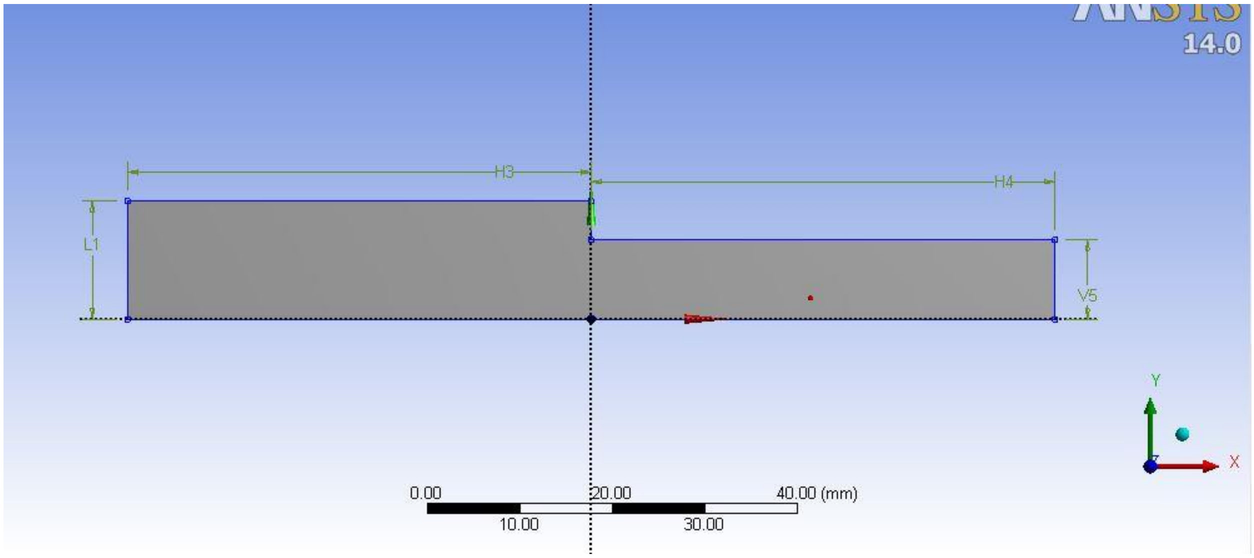


Fig 5.7: geometry of sudden contraction

b) Meshing

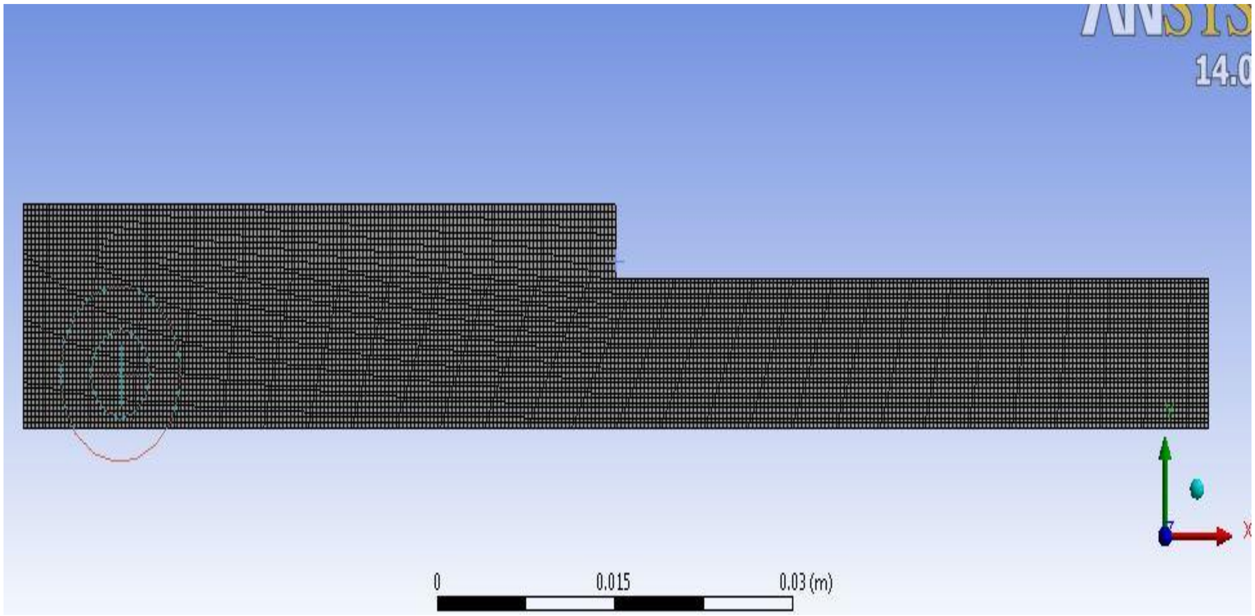


Fig 5.8: Mesh of sudden contraction

c) Stream Function

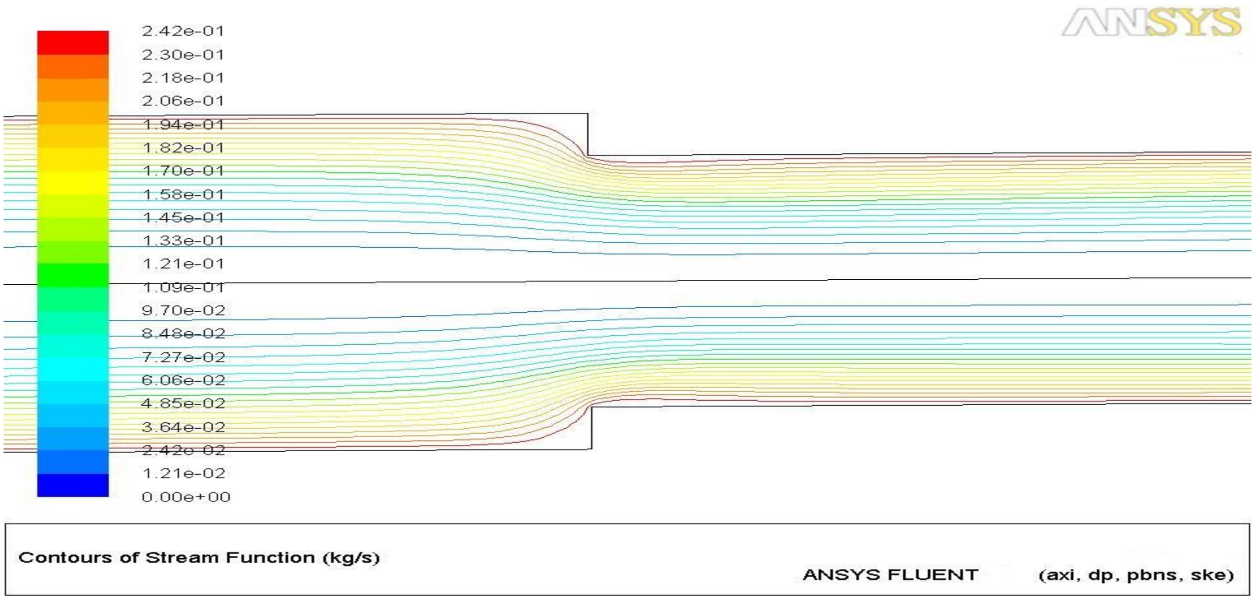


Fig 5.9: Contour of Stream function

In above fig 5.10 we can show that stream line changes their path at junction and minimum area of flow occur at just right of the junction which is known as a vena-contracta.

d) Absolute Pressure

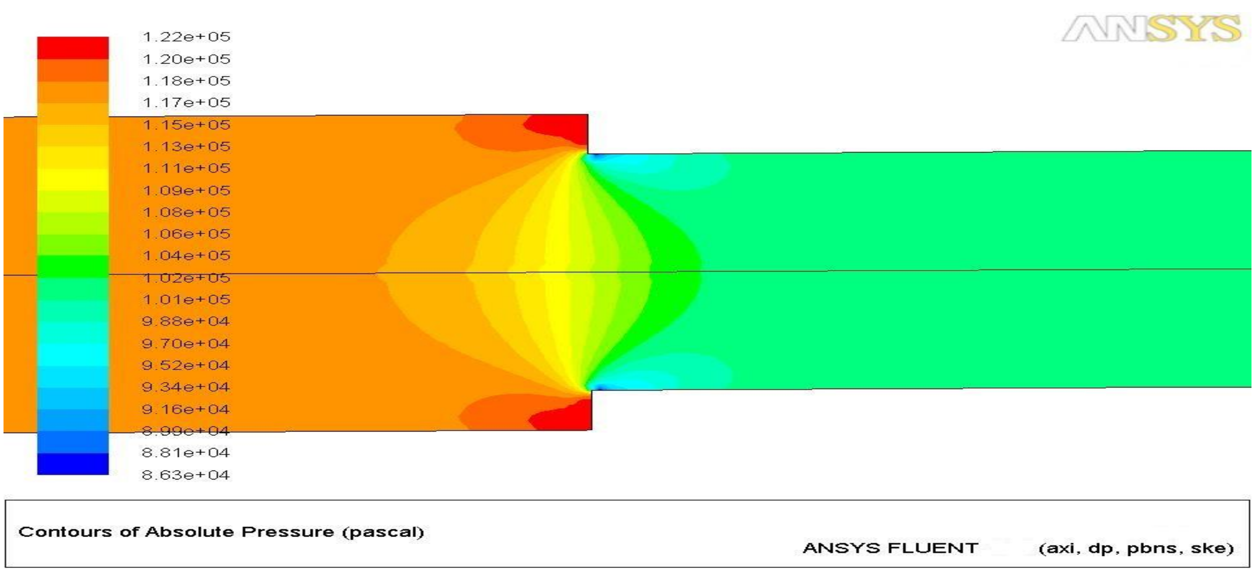


Fig 5.10: Contour of absolute pressure

Presssure decreases when flow is contracted at the junction pip surface having very high pressure, and at outlet (smaller diameter) pressure is higher than having lower diameter.

e) Velocity

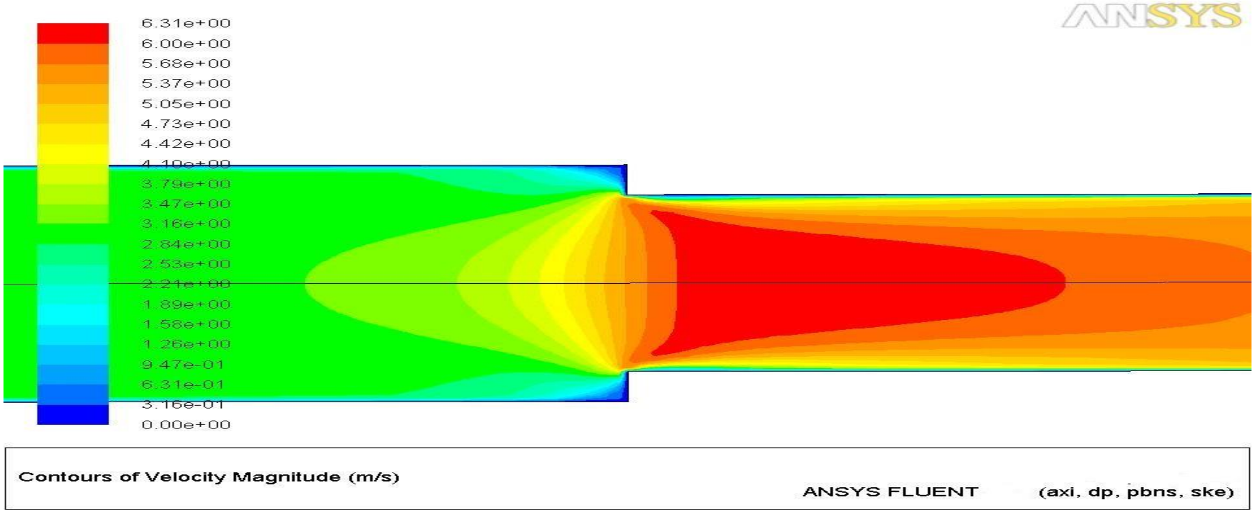


Fig 5.11: contour of velocity

Velocity increases when stream enter in smaller diameter and velocity is maximumm at vena-contracta because area of flow is minimum at that place.

f) Dynamic pressure

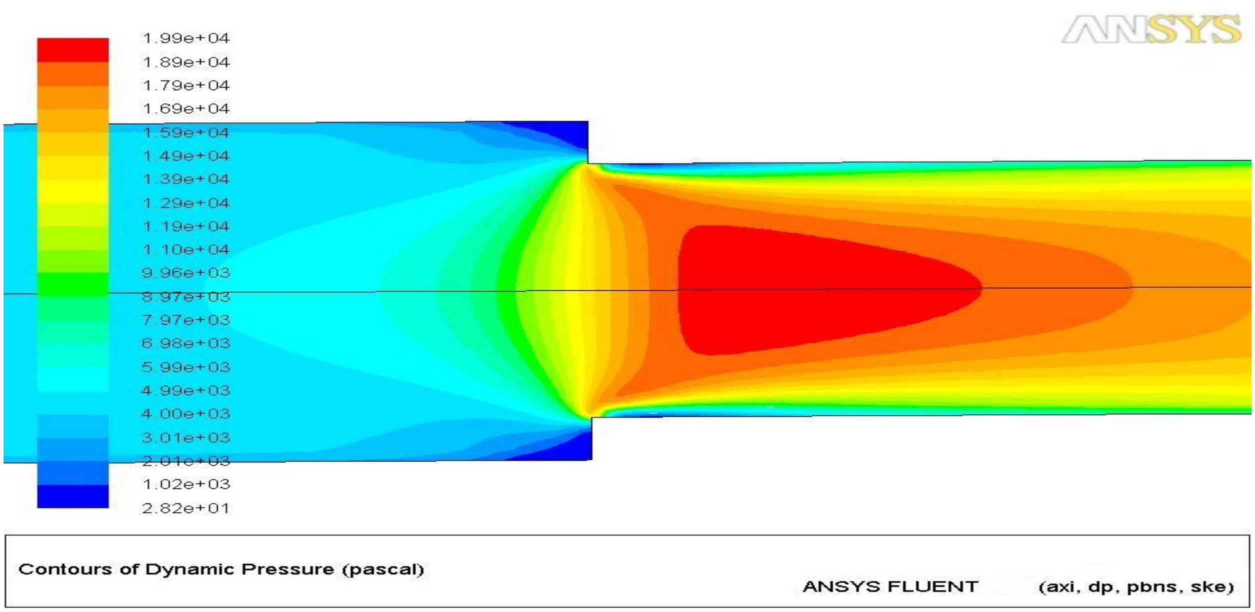


Fig 5.12: Contour of Dynamic pressure

It is nearly same as velocity profile because, it is directly propotional to square of velocity.

g) Static pressure

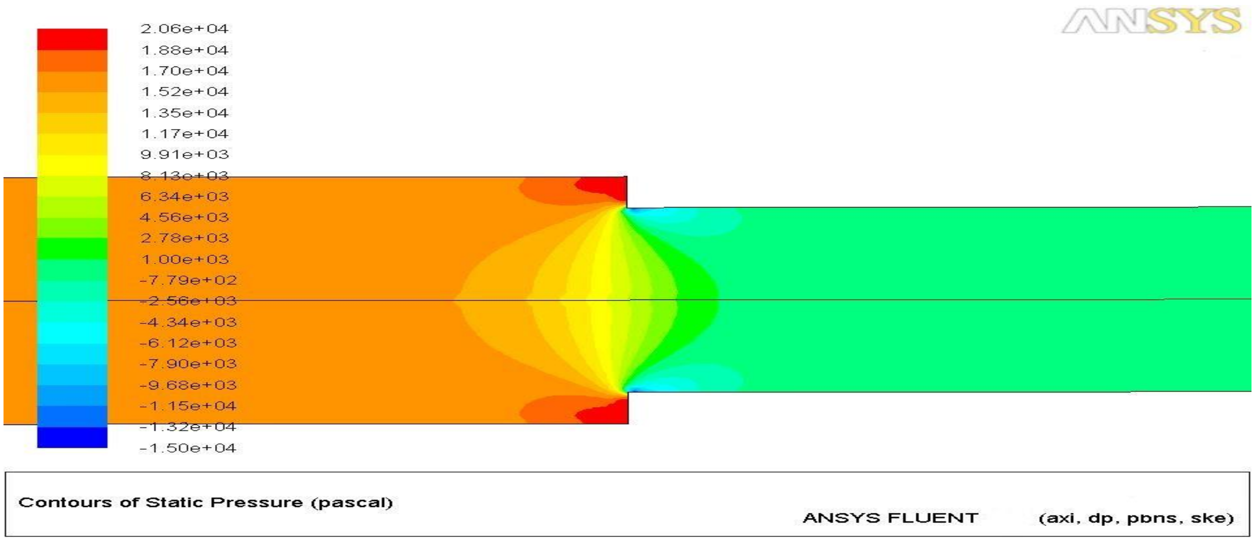
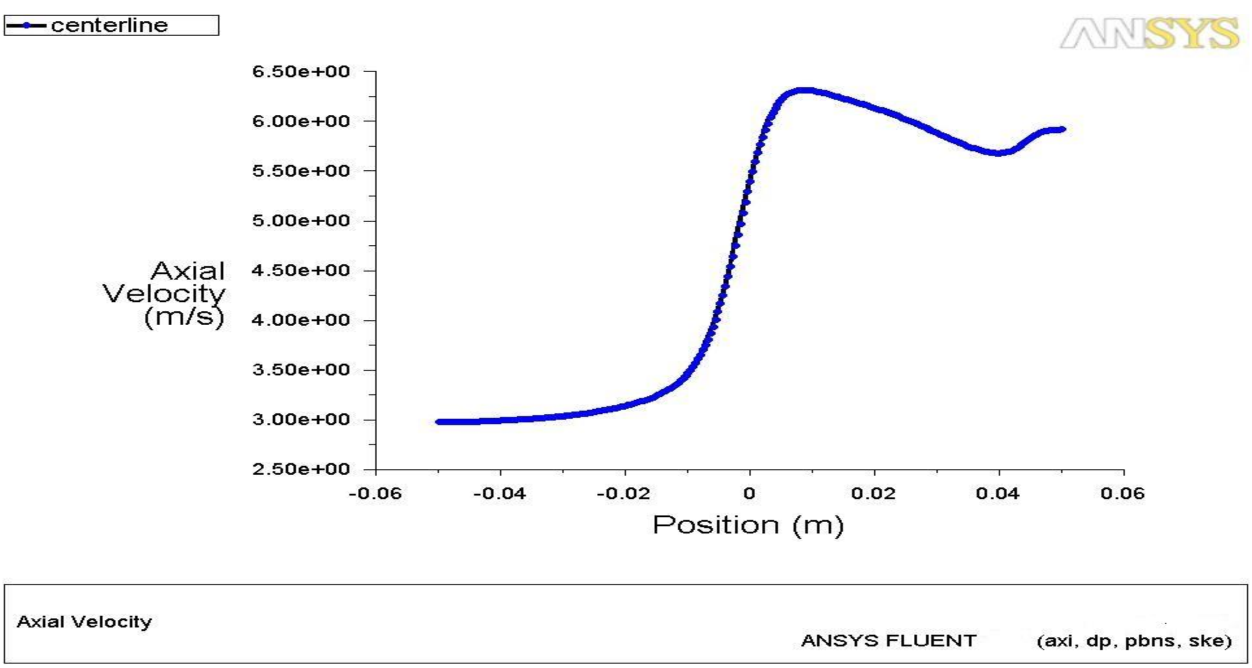


Fig 5.13: Contour of static pressure

From above Fig 5.14 we can show that there is loss in static pressure between inlet and outlet.Pressure at inlet (pipe having large diameter) is more than the outlet (pipe having smaller diameter).



Graph 5.3:

From aboove graph 5.3 it can easily seen that velocity increased suddenly at the junction and maximum velocity occur at just right of the junction (ie. At vena-contracta).

5.2.2 CALCULATION

Pressure at outlet=1.52$\times 10^4$Pa.

At inlet=1.17$\times 10^4$Pa.

Difference in pressure=3.5$\times 10^3$Pa.

Head difference=$\frac{3.5\times10^3}{1000\times9.81} = 0.356m$

For pipe 1 and $v_2 = 5.29m/s$

$$h_c = k_c \times \frac{{v_2}^2}{2g};$$

$$k_c = \frac{2gh_c}{{v_2}^2} = \frac{2 \times 9.81 \times 0.356}{5.29^2} = 0.25$$

5.3 BEND

5.3.1 EXPERIMENTAL OBSERVATION AND CALCULATION:

OBSERVATION

Table 5.4 for bend

Sl No	Rise in level(cm)	Volume (cm^3)	Time (sec)	Discharge (m^3/sec)	Manometer Difference(mm)	Head (m)	v (m/sec)	K_b
Pipe 1	10	9000	6	1.5×10^{-3}	14.2	0.1786	2.96	0.4
Pipe 1	10	9000	9	1×10^{-3}	7	0.09	1.97	0.45
Pipe 2	10	9000	7	9×10^{-4}	16	0.1984	3.16	0.39
Pipe 2	10	9000	14	6.21×10^{-4}	8	0.1	2.18	0.41

5.3.1 CALCULATION:

For pipe 1 and velocity 2.96 m/s

$$h_b = k_b \times \frac{v^2}{2g};$$

$$k_b = \frac{2gh_b}{v^2} = \frac{2 \times 9.81 \times 0.1786}{2.96^2} = 0.4$$

For pipe 2 and v=3.16 m/s

$$k_b = \frac{2gh_b}{v^2} = \frac{2 \times 9.81 \times 0.1984}{3.16^2} = 0.39$$

5.3.2 FROM ANSYS

a) Geometry

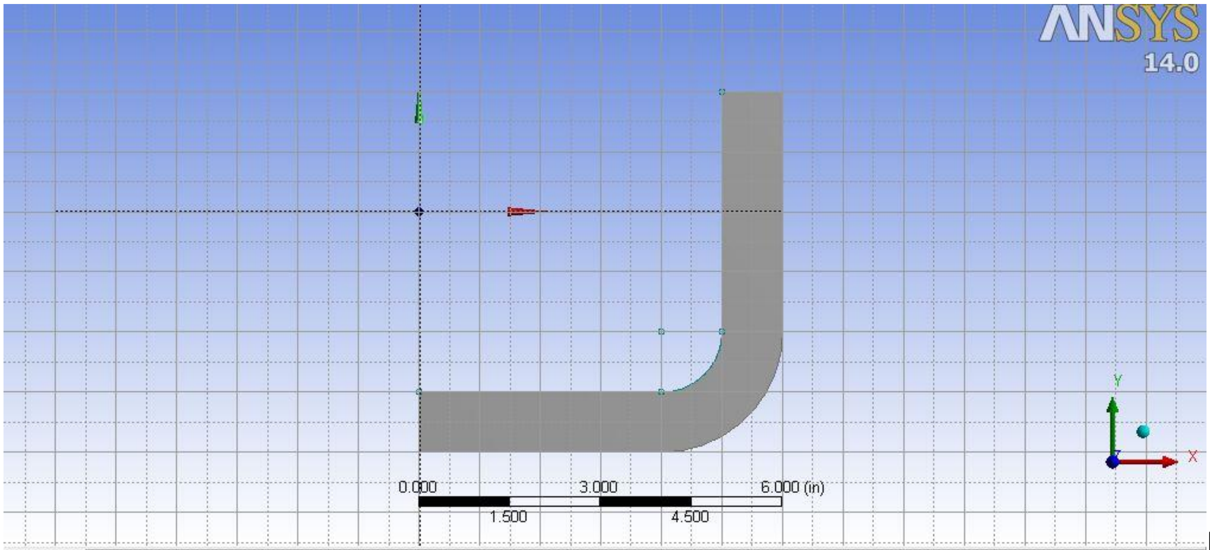


Fig 5.14: geometry of elbow

b) Mesh

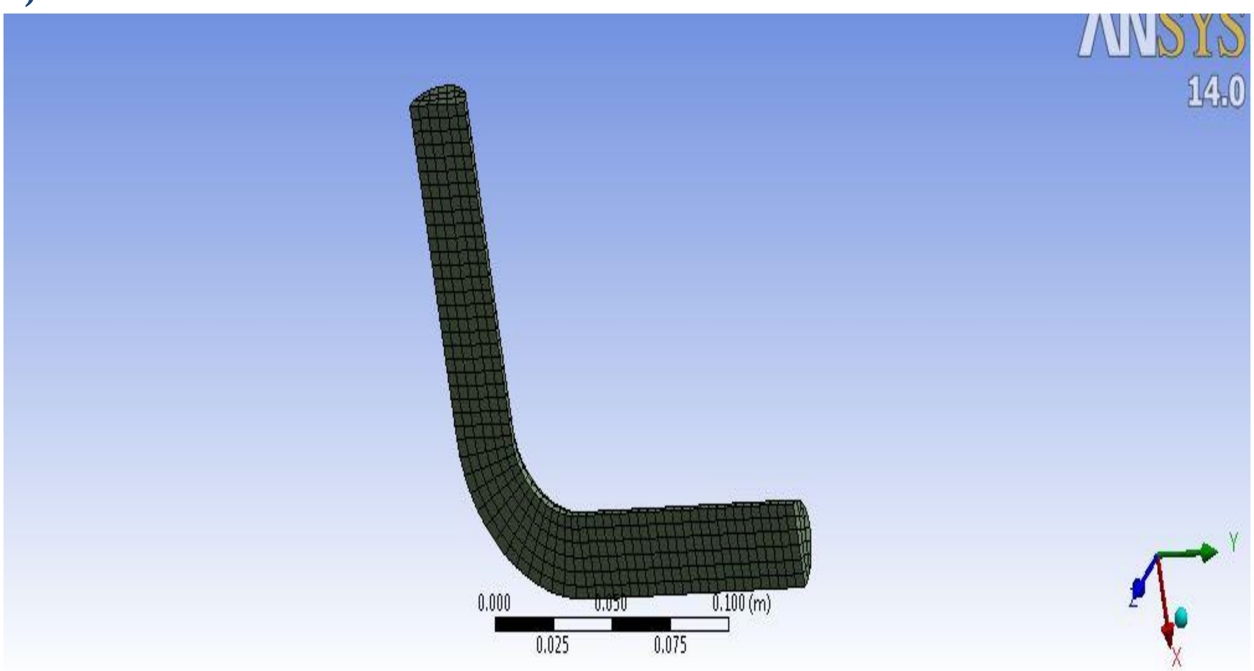


Fig 5.15: mesh of elbow

c) velocity

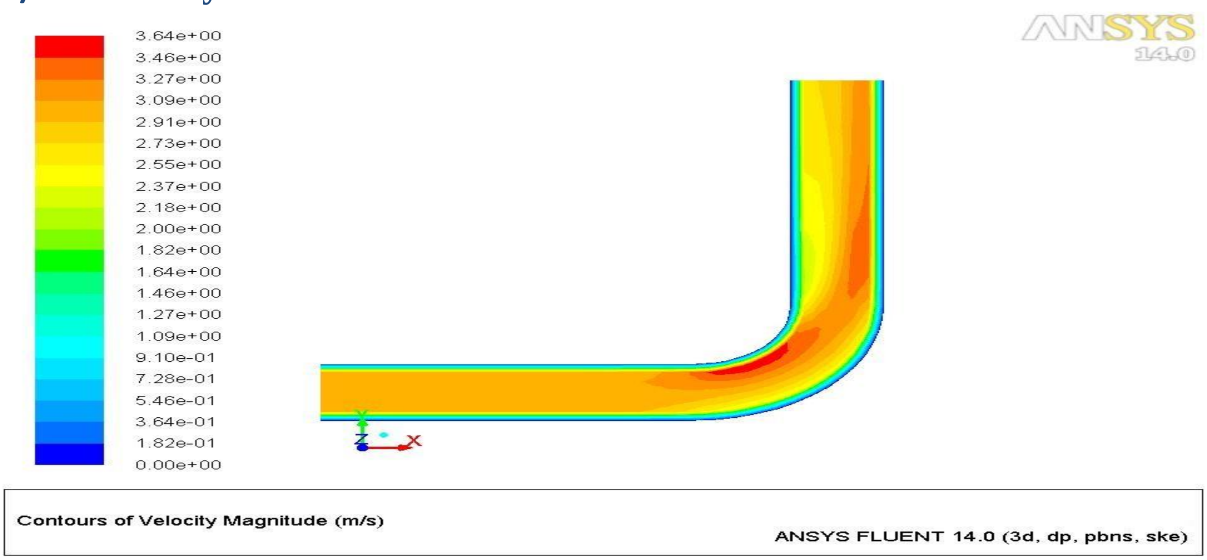


Fig 5.16: contour of velocity

Velocity is maximum at the bend because due to change in direction area of flow is contracted.

d) Dynamic pressure

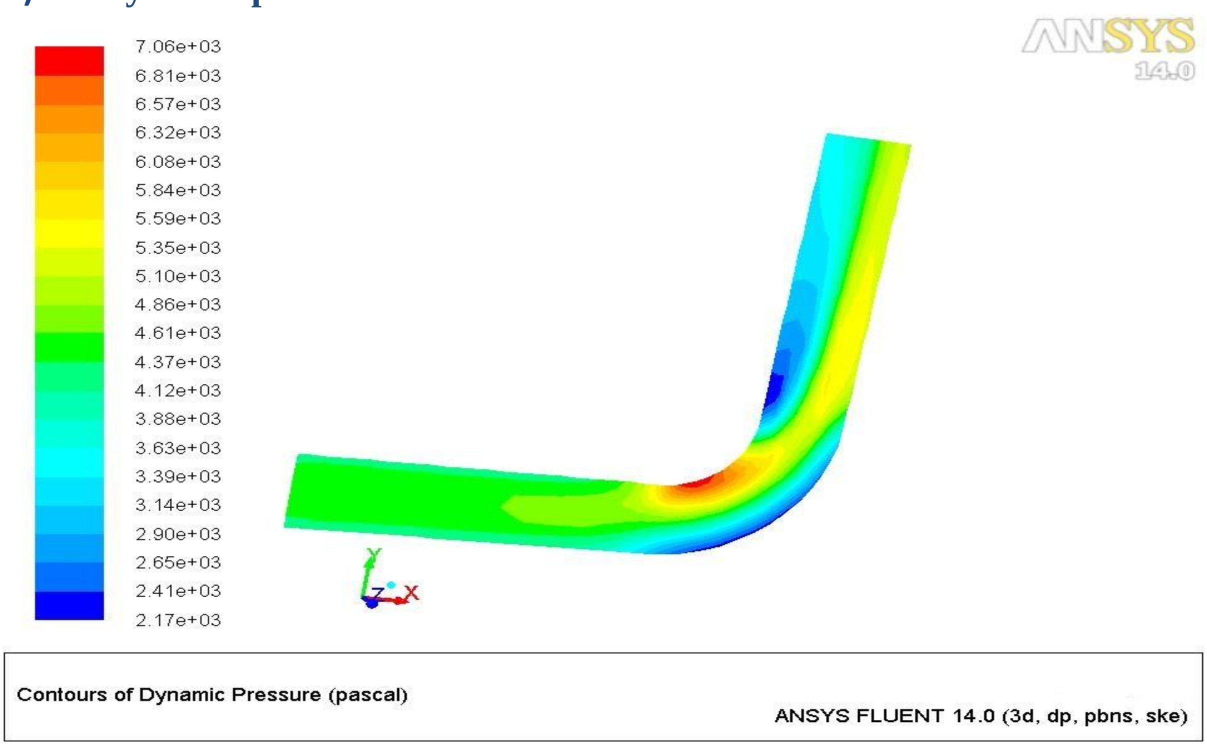


Fig 5.17: Contour of dynamic pressure.

e) Static pressure

Fig 5.18: contour of static pressure

Static presure increases at the bend and after the bend static pressure decreases gradually.

f) Turbuent intensity

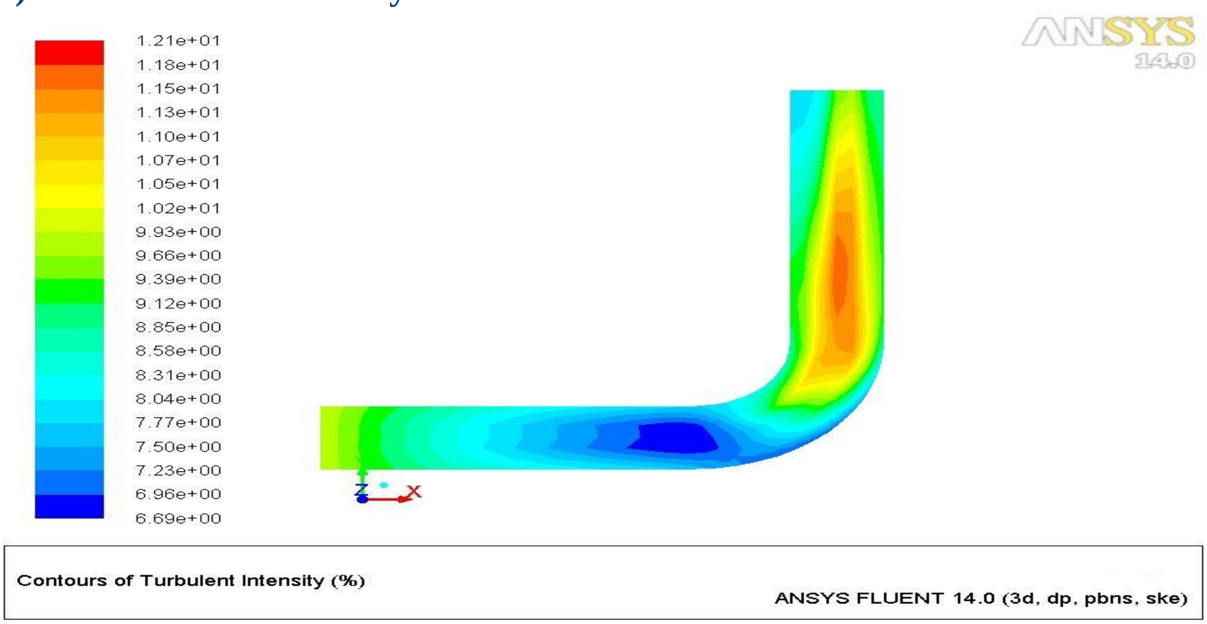


Fig 5.19: contour of turbulent intensity

Due to bend, intensity of turbulent is increase because due to bend formation of eddies occur at bend.the colour and red colour shows maximum intensity.

g) Static pressure of straight pipe

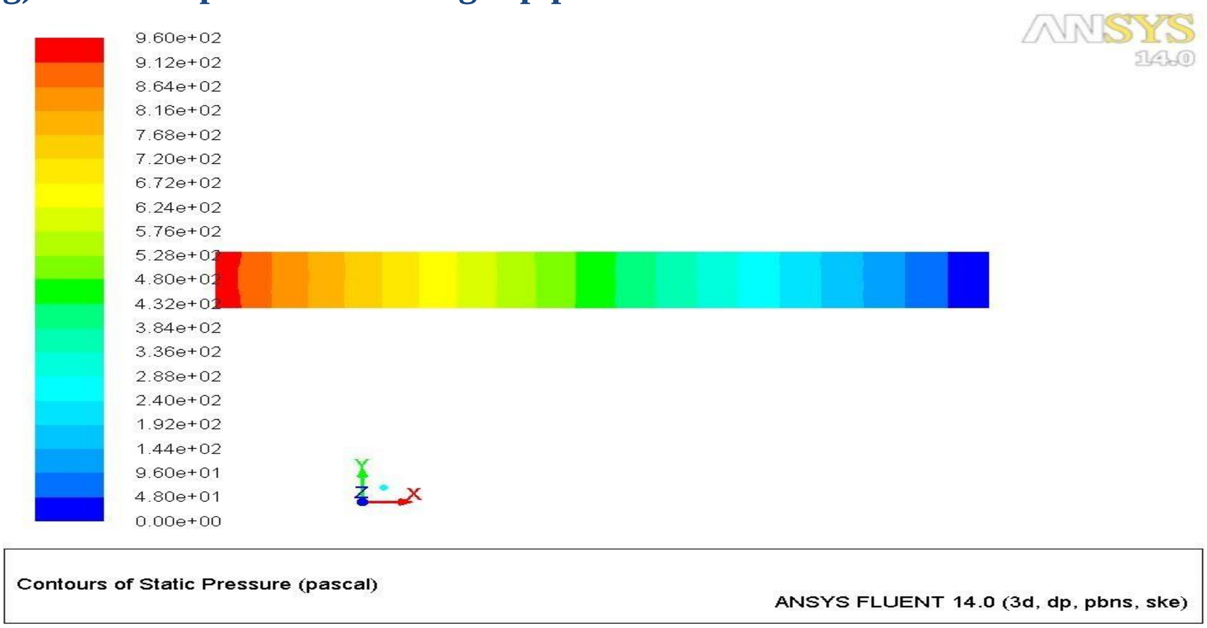


Fig 5.20 Contours of static pressure of straight pipe

5.3.2 CALCULATION

Static pressure (in pascal) for bend pipe
Inlet pressurre= 2.07×10^{3}
Outlet pressure= -3.76×10^{2}
Difference = $2.446\text{x}10^{3}$
Difference between inlet and outlet of straight pipe=9.6×10^{2}Pa

Net pressure loss=$2.446\times10^{3}-9.6\times10^{2}$=1486 Pa

$$Head\ loss = \frac{pressure\ difference}{\rho g} = 0.151m$$

Now,

$$k_b = coefficient\ of\ bend = \frac{2gh}{v^2} = \frac{2\times 9.8\times 0.151}{2.96^2} = 0.34$$

CHAPTER6

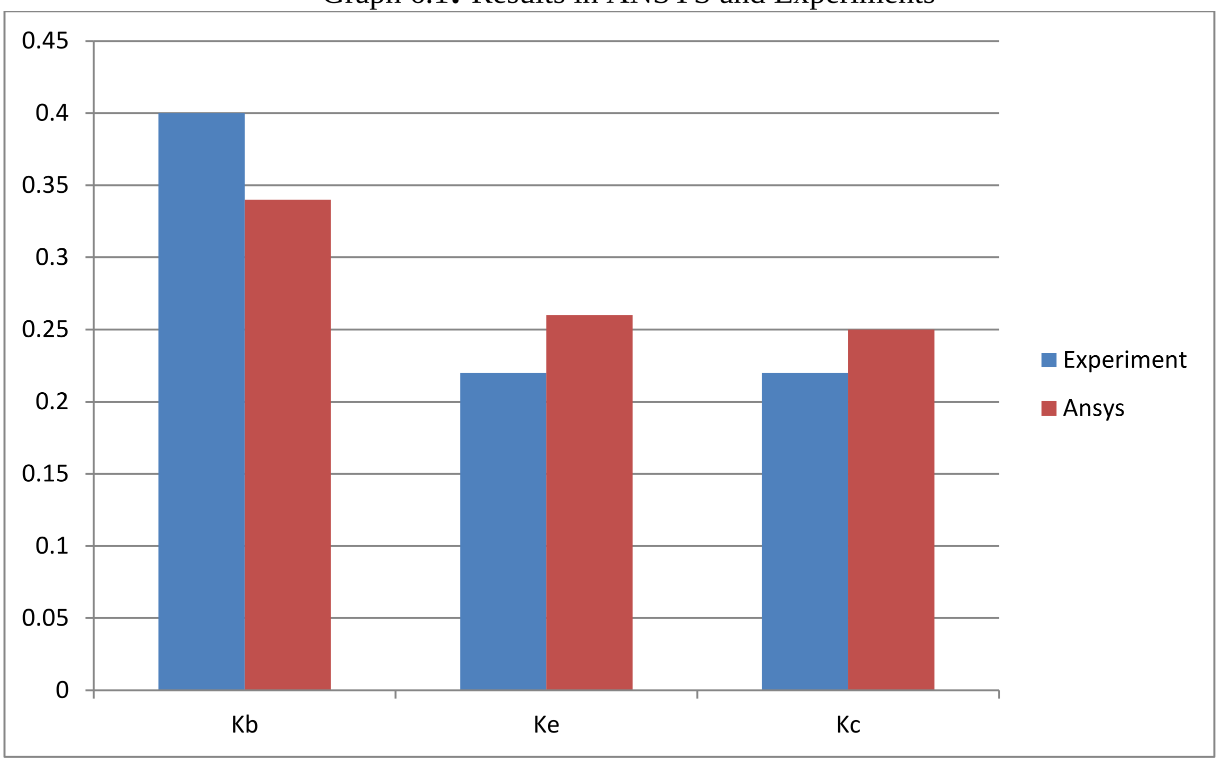
ANALYSIS OF RESULTS

6.1 COMPARISON BETWEEN ANSYS AND EXPERIMENTAL RESULTS

Table 6.1: Results in ANSYS and Experiments

RESULT	K_b	K_e	K_c
From experiment	0.4	0.22	0.22
From ANSYS	0.34	0.26	0.25

Graph 6.1: Results in ANSYS and Experiments



CHAPTER 7

CONCLUSION

CONCLUSION

- Loss co-efficient of bends is slightly more in experimental results than result obtained from ANSYS. The difference between results is very less means values are almost same.
- Loss co-efficient of contraction is slightly more in ANSYS results than the result obtained from experiments. The values of result are almost same.
- Loss co-efficient of expansion is more in ANSYS results than the result obtained from experiments. In this geometry also the results obtained from both ANSYS and experiment are almost same.

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